LUNAR CORE DETECTION USING DATA FROM A SINGLE ORBITING MAGNETOMETER: A FEASIBILITY STUDY. L. L. Hood and K. Hartdegen, Lunar and Planetary Lab, University of Arizona, Tucson AZ 85721.

The mass of a possible iron-rich lunar metallic core is a basic constraint on lunar bulk composition and, hence, lunar origin models [1,2,3]. In principle, an accurate measurement of the induced magnetic dipole moment of the Moon after exposure to a uniform magnetic field in a near vacuum environment could be used to infer the radius of such a core. The analytic approach involves estimating the induced moment when the Moon is in a lobe of the geomagnetic tail where the field is most nearly spatially uniform and the plasma density is relatively low and undisturbed. This approach has previously been applied using data from the Apollo 15 and 16 subsatellite magnetometers [4]. A similar approach may be applied using Lunar Prospector magnetometer data provided that certain theoretical issues are resolved. Here, we consider only the measurement issue. Specifically, we report an investigation of the detectability of a lunar core in the presence of realistic magnetic field and plasma disturbances in the geomagnetic tail at distances comparable to the lunar orbit radius (about 60 R_E). ISEE-3 magnetometer and plasma data are employed for this purpose.

Because of the high temperature of the lunar interior and the minimal free iron content of the crust, the lunar induced moment is due almost entirely to electrical currents flowing in the lunar mantle and core which oppose any external magnetic field change. The induced moment is therefore oriented opposite to the applied field change. After a period of the order of a few hours following an external magnetic field change, induced currents in the mantle will have decayed and the residual moment will result from currents flowing on the surface of the core. Assuming that a lunar core exists and that the radius is known, it is straightforward to calculate the amplitude of the expected residual moment. We investigate here whether such a small induced moment would be detectable using ISEE-3 magnetometer and plasma data for the period October 1982 to April 1983 (R. Lepping and P. Riley, private communication, 1995).

During December 1982 and April 1983, the ISEE-3 orbit trajectory was especially well suited for simulating field and plasma measurements at lunar distances in the geotail. Passes through the geotail were identified by examining both electron number density and magnetic field component plots as a function of time. Within the tail lobes, the electron density dropped to nearly zero and the field became oriented toward (North lobe) or away (South lobe) from the sun. After rotating to geocentric solar ecliptic (GSE) coordinates, the GSE x-component has an amplitude of order 10 nT (1 nT = 10^{-5} G) at lunar distances while the y- and z-components are nearly zero. For example, during December 1982, an interval of approximately 2.5 days can be identified when ISEE-3 was in a geotail lobe and the field was relatively constant and oriented toward the sun. We assume that an induced field is present due to the existence of a core with a given radius in the presence of a 10 nT uniform field.

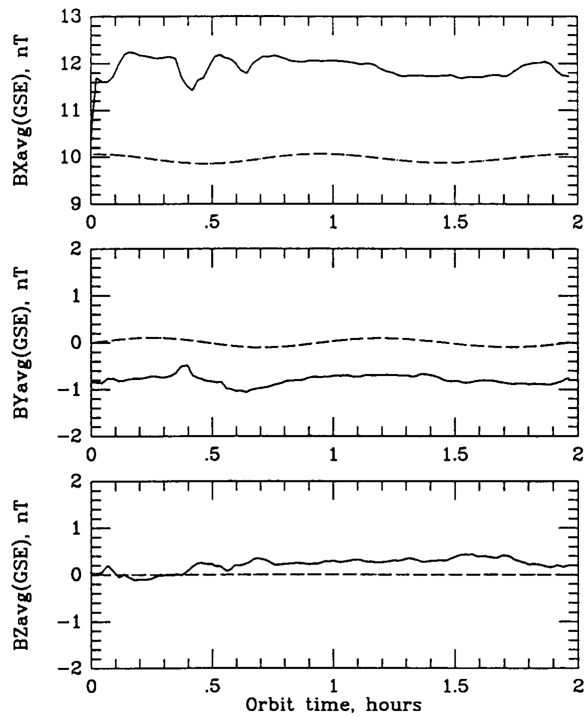

Fig. 1.

To simulate lunar orbital magnetometer measurements of this induced field, we add the ISEE-3 field components (minus 10 nT in the GSE x direction) to the simulated lunar orbital field components. Induced fields due to short-term (<1 day) geotail field fluctuations are neglected. A total of 24 2-hour "orbits" of field measurements were simulated in this manner. We have further assumed that the orbit of the lunar satellite is polar and is parallel to the GSE xy plane.

As a test case, Figure 1 shows the result of assuming an induced field due to the presence of a core with a radius of 435 km. The dashed curves in each field component plot represent the expected induced magnetic field components. The solid lines represent averages of the simulated lunar magnetic field data over all 24 available "orbits." As can be seen, the GSE x-component (parallel to the applied field) was not sufficiently steady to allow detection of the induced field, even after substantial averaging. However, the GSE y-component (center panel) was steady enough so that the induced field component in this direction is marginally detectable. We conclude on the basis of this simulation that a lunar core induced magnetic moment, if present, would be marginally detectable using data from a single orbiting magnetometer provided that the core is larger than about 400 km in radius. Averaging of more orbits than considered here would allow a smaller core to be detected. Moreover, if a second magnetometer exists in the geotail in the lunar vicinity during the period of lunar orbital measurements, it may be pos-sible to subtract out much of the ambient field variations (except for high-frequency lunar induced fields). This would make a core induced field more detectable with fewer measurement orbits.

References: [1] Lunar Exploration Science Working Group (1992) *A Planetary Science Strategy for the Moon*, Johnson Space Center (JSC-25920); [2] Hood, L. L. (1986) in *Origin of the Moon* (W. K. Hartmann et al., eds.), pp. 361–410, LPI, Houston; [3] Hood, L. L. and J. Jones (1987) *Proc. Lunar Planet. Sci. 17th*, in *J. Geophys. Res.*, *92*, E396–E410; [4] Russell, C. T., P. J. Coleman Jr., and B. E. Goldstein (1981) *Proc. Lunar Planet. Sci. Conf. 12th*, pp. 831–836.